

Diode-Laser Holographic-Imaging System Applied to the Study of Fluids in Microgravity

William K. Witherow/ES76
205-544-7811

Holography is an important research method because it records an image of the entire volume of a test cell at a given instant in time. When a hologram is constructed, it records the wavefront coming from the test cell; when the hologram is reconstructed, the same wavefront is reproduced. The reconstructed wavefront can be analyzed by the same optical techniques that could have been used on the original test cell.

This capability is important in many areas of research, including solution crystal growth, fluid physics, and particle phenomena. As an example, quantitative studies of transparent dispersion growth require diameter measurements from numerous microscopic droplets at a given instant in order to produce statistically significant results. Typically, the droplets will be undergoing changes in position or size as the experiment progresses. Accurate measurement of the entire population of droplets is impossible by normal techniques. However, by recording a hologram of the experiment, the entire test-cell volume is stored. The entire test cell from the reconstructed hologram can be investigated by microscopy to measure all of the droplets.

The primary objective of the proposed research is the development and testing of a compact, state-of-the-art, modular, holographic-imaging system based on diode-laser technology, incorporating micro-optics in order to record full three-dimensional images of the test cell. The apparatus has been designed to be compatible with a variety of test-cell modules. The device is suited to applications in ground-based laboratories, as well as reduced-gravity environments, e.g., the space shuttle, the KC-135 aircraft, and sounding rockets.

A second objective of the research is to develop a compact apparatus designed for microgravity fluid-physics studies. This fluids module will be designed to plug in to the imaging system, and will be used in order to verify that system's functionality. Several fluid-handling functions will be incorporated, including the ability to (1) produce well-defined dispersions having user-specified characteristics, (2) deploy numerous small droplets of selected volumes, and (3) deliver selected volumes of fluid.

An initial breadboard system has been constructed to test the capabilities of the diode laser to construct holograms. In-line holograms have been made of static glass beads (approximately 200 microns in diameter) suspended in water and of calibration test patterns. Side-band holograms of melting ice in water have also been made. The capabilities of the initial system are being evaluated. A fluids-processing module was developed for the KC-135 flight with heating and mixing capabilities.

A miniaturized holographic system will be designed based on current optics technology. An optics breadboard table, on which the system will be constructed with miniaturized optical components, is the same size as a shuttle locker. Once constructed, the system will be tested and refined, and a variety of experiments will be performed to demonstrate its capabilities. The holographic system and the microgravity fluids module will be combined and tested on the KC-135.

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